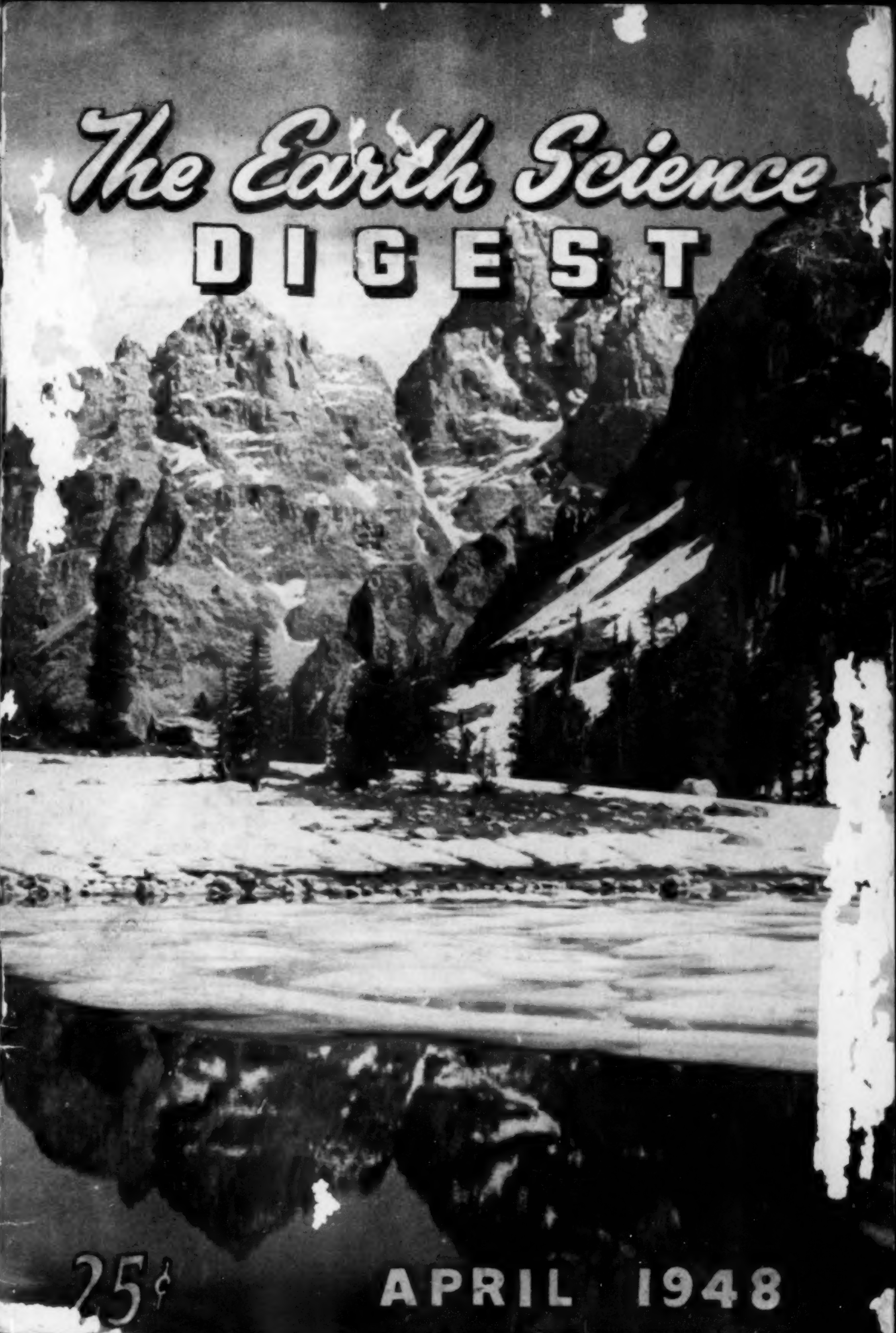
The Earth Science DIGEST



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The Earth Science Digest

Revere, Massachusetts

A magazine devoted to the advancement of the geological sciences.

THE EARTH SCIENCE DIGEST is open to articles of geologic interest. Manuscripts, photographs and sketches will be returned if accompanied by ample first-class postage.

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S. Albert Eisenberg, Publisher
Gertrude Roberts, Business Manager

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Contents

COVER PHOTO

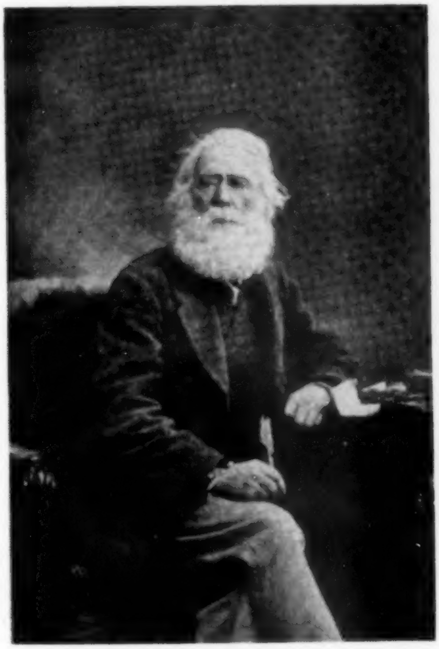
The lofty Teton Range, as seen from Jackson Hole, Wyoming, presents a familiar panorama to thousands of Americans. However, a climb into the range reveals even more entrancing views. The photo was taken on the shore of Lake Solitude, a high mountain lake which was still partly frozen in mid July. The view is to the east, in the direction of the Grand Teton. Photo by H. P. Zuidema, University of Michigan.

THE FATHER OF CANADIAN GEOLOGY

The Story of Sir William Logan

E. J. ALCOCK

Curator, National Museum of Canada



Sir William Edmund Logan

Sir William Logan was the founder and first director of the Geological Survey of Canada, but he was something more. For the 27 years of his association with it, he, in his own person, practically constituted the Survey. During that time he built up an organization of enthusiastic assistants, but he himself always remained the most active worker, the guiding spirit, and the one whose passion for research and accomplishment inspired all his associates. Throughout his lifetime the worth of his character and the value of his contributions were recognized not only in the country he was serving but everywhere the science of geology was pursued, and the passing time has not dimmed but rather has enhanced his reputation. Wherever more recent workers have followed in his footsteps there has been uniform respect for the conclusions he reached and the work he performed. It is small wonder, therefore, that his name is the most prized heritage that the Geological Survey possesses.

William Edmund Logan was born in Montreal on April 20, 1798, of well-to-do Scotch parents. His early education was received at an excellent private school in that city, where in addition to a grounding in the classics he seems to have acquired the capacity to thrash boys bigger than himself. In 1814 he and his brother were sent to Scotland to attend Edinburgh High School, and two years later his father carried on a plan, which he had long been contemplating, of returning to his native land to live. Leaving his eldest son, James, to carry on the Montreal business, he brough the rest of the family to Edinburgh, and soon two other sons, Edmund and Henry, joined their brothers at the High School. This was a famous institution that drew its pupils from a wide range of society, noblemen's sons sitting alongside the sons of tradesmen, and it numbered among its graduates many distinguished men. The Logan boys, particularly William, all did well in their studies, but at this time Wiliam's heart seems to have been set on a commercial career, and in 1817 he went up to London to enter the counting-house of his uncle, Mr. Hart Logan. For the next fourteen years the busy metropolis was his home; his family continued for a time to live in Edinburgh, but in 1820 his father purchased a small estate some twenty miles from Edinburgh, near the Avon, and Clarkstone, as it was called, became the scene of many happy family reunions.

This month marks the 150th anniversary of the birth of Sir William Logan, the father of Canadian geology. Sir William was one of the really great men of geology and therefore the **Earth Science Digest** thought it fitting that he be honored in some way on this occasion of his birth. We take great pleasure in presenting this story of his life, written by F. J. Alcock, Curator of the National Museum of Canada. This story was originally prepared for the occasion of the one hundredth anniversary of the founding of the Geological Survey of Canada as part of the booklet "A Century in the History of the Geological Survey of Canada", and was later printed in the **Canadian Mining Journal.** It is reprinted with the permission of the author and the editor of the **Canadian Mining Journal.**

Logan's sojourn in London was occupied largely with business, but there was time for travel, society, and study. His favorite reading was on chemistry, mineralogy, and geology, but it was not until after he left London that he discovered that he wished to make the study of these his life work. In 1831 he went to Swansea, Wales, to join the staff of a copper-smelting business in which his uncle had invested considerable capital. At first his time was employed in the office, where he toiled from early morning until midnight in order to establish a proper system of accounts, but eventually he had to attend to technical matters in connection with copper smelting and with the mining of coal required for the smelting operations. His efforts with the second of these soon aroused his interest in the structure of the local Glamorganshire coal field. He purchased a theodolite, compass, and other instruments and devoted himself to the preparation of a detailed geological map of the region. The work was done with such care and thoroughness that when Sir Henry De la Beche began his geological survey of the region he accepted Logan's offer of his maps and adopted them *in toto* for the government survey. During his work in Wales, Logan's fondness for geology steadily increased. In 1837 he was elected a Fellow of the Geological Society and in 1840 he read a paper before that body on the origin of coal that was regarded as a most important contribution to the subject. It has been recognized that coal is of vegetable origin, but the exact manner in which it has accumulated was in dispute. Some regarded the seams as having been deposited in the manner of driftwood in lakes or at the mouths of rivers draining wooded country, whereas a second school was of the opinion that they had grown in the manner of peaty swamps. Logan's observations showed that beneath the coal seams he had investigated there was everywhere a layer of clay in which were roots of the trees from which the coal was produced, and his conclusions were that the coal had grown *in situ*.

During his long stay in Britain, Logan never lost his love for his native Canada and now that geology was his chief interest in life he longed to study the rocks that he had seen as a boy, and that still remained a virgin field for investigation. In 1840 he went to Montreal on a visit, and in the following year, before returning to Britain, he spent considerable time in Nova Scotia and the eastern United States looking over geological sections and studying in particular the coal measures of these fields. At this time the Government of Canada, which then comprised the two provinces Upper and Lower Canada, now Ontario and Quebec, was considering a proposal to have a geological survey made of the country, and Logan was very desirous to undertake the work. His name was suggested by friends in Montreal to the Governor, Sir Charles Bagot, and recommendations came from Sir Henry De la Beche, Director of the Geological Survey of Great Britain, and from other eminent British geologists, with the result that in the spring of 1842, Logan was offered the appointment. He secured, as assistant, Alexander Murray, a young man with naval training, and very much interested in geology, who subsequently became the Director of the Survey of Newfoundland, and in 1843 the two began field work in Canada, Murray in the region between Lake Huron and Lake Erie, and Logan in Gaspe.

At that time small settlements composed chiefly of fishermen were scattered along the Gaspe coast, but of the interior of the peninsula little was known except locally to a few lumbermen and Indians. There were rumors of coal, however, and Logan felt that here was an excellent place to begin work. Accompanied by a helper named Stevens, and an Indian, John Basque, he spent his first field season examining the rocks of the coast from the towering cliffs near Cape Rosier, at the eastern end of the peninsula, to Paspebiac on Chaleur Bay, a distance of about 100 miles. Distances were measured by pacing along the shore while the Indian followed with the canoe and equipment, occasionally ferrying Logan around projecting cliffs or over places too deep to wade. In the evening camp was pitched, the notes of the day were written up, survey measurements plotted, often by the glare of the campfire, and then came the well-earned rest on a bed of spruce boughs.

Logan's collecting basket.

In the following year Logan, with a larger party, including Murray, mapped the north shore of Gaspe and then made an exploration across the middle of the peninsula. Cap Chat River was ascended and surveyed in canoes to its headwaters in the mountains. Adjacent summits were climbed, on the highest of which a Union Jack was planted, and to which Logan's assistants insisted on giving the name Mount Logan. Where the stream became too small for further travel in canoes, these were sent back and the remainder of the party continued southward on foot, Logan keeping a pace and compass traverse as he went. Eventually southward flowing waters were reached at Goashore Brook, a headwater tributary of Cascapedia River. New canoes of spruce bark were then built and in them the party descended to Chaleur Bay. Logan's survey, when plotted, tied in almost exactly with the two end points as they appeared on the admiralty charts. In addition, he had secured a geological section across the whole peninsula and was able to say that, because all the rocks were older than those that carry coal, no coal deposits are present in the peninsula. Since Logan's day much geological exploration has been carried out in Gaspe, but his work laid the foundation of our geological knowledge and settled the larger problems.

In the early days of the Survey, Logan had many problems other than those of geology. He required quarters for his specimens and for an office, and for this he first of all obtained from his brother James the use of an "upper chamber" in the latter's warehouse on St. Gabriel Street, but early in 1844 he hired a house at No. 40 Great St. James Street, which served as Museum, office, and laboratory. Then, by the end of 1844, the £1,500 that the Government had voted for the work of the Survey had all been spent together with £800 of Logan's own money. He was requested by the Government, however, to prepare an estimate of the cost of continuing the Survey. This was done and a bill was also drawn up and submitted for the consideration of the members of the Legislature. It met with approval and was enacted on March 17, 1845, providing £2,000 a year for 5 years. Scarcely, however, had this matter been settled when Logan was called upon to make an important decision. An offer came to go to India to take charge of a Geological Survey there. It was very tempting but Logan decided that he preferred to continue the work in which he had become so much interested in his own country.

Close-up view of the old McGill Residence, St. Gabriel Street, Montreal.

In 1846 the Survey's offices were moved to a larger building in Little St. James Street that was leased from the Natural History Society. Here they remained until 1852 when once more they were removed to more commodious quarters, the former residence of the Honourable Peter McGill, St. Gabriel Street, where they remained for the rest of Logan's regime. In 1850 the vote of money for the Survey was renewed for another 5 years, and in 1855 a Select Committee, appointed to inquire into the operation and usefulness of the Geological Survey, recommended that increased facilities be provided for the work. The result was that a new Act was passed affording $20,000 annually for 5 years and a sum of $8,000 for publishing a map and a report on the geology of Canada.

After the expiration of this renewal act supplies of money were voted annually until 1864 when another act was passed making provision for the Survey for another 5-year period.

Logan's troubles over quarters and funds did not hamper his field work or his scientific investigations. Surveys were carried westward, up the Ottawa, through Lake Timiskaming, and on to Lake Superior. Througout this region he had to deal with Precambrian rocks, and though he had no previous experience in this branch of geology his conclusions have won the respect of later specialists in this field. Extensive surveys were also made in the Eastern Townships and other parts of Quebec. Detailed topographic maps were made to serve as a base on which to show the geological information, specimens were collected, mineral deposits visited and reported upon, and Annual Reports of Progress issued. His magnum opus, however, is the Geology of Canada, 1863, a volume of 983 pages in which he reviewed and revised all the work of the Survey up to that date. Three years later appeared his geological map of Canada, showing the geology and geography of southeastern Canada as far west as Manitoba and as far north as Lakes St. John, Timiskaming, Nipigon and St. Joseph.

Still another phase of Logan's activity was his efforts to advertise Canada's resources abroad. In 1851 he took an exhibit of Canadian minerals to London for the "Exhibition of the Industry of all Nations". This received very high praise and Logan was presented with a medal by Prince Albert, President of the Committee for the Exhibition. He was also at this time made a Fellow of the Royal Society, the first native Canadian elected for work done in Canada. In 1855 he showed another exhibit at the Paris Exposition, and for this he received the Grand Gold Medal of Honour and in addition he was presented by the Emperor Napoleon III with the Cross of the Legion of Honor. A greater distinction, however, awaited him at the hands of his own sovereign. Queen Victoria paid a visit to the Exhibition and Logan had the honor of explaining the Canadian exhibit to her. She was impressed by his enthusiasm and by his charming manner and shortly after, on January 29, 1856, she knighted him at Windsor Castle. About this time, too, he received from the Geological Society the highest honor in its power to bestow—the Wollaston Medal. Laden with all these distinctions Logan returned to Montreal to be presented by his many friends in his home city with a magnificent silver fountain with several basins, one above another, on which were engraved pictures of Carboniferous flora, symbolical of his researches in the coal-bearing rocks.

Logan had looked forward to the time when the activities of the Geological Survey would be carried both eastward and westward through British North America. Especially was he interested in reports of the occurence of coal in what is now Alberta and British Columbia. When Confederation of the Maritime Provinces with Canada came in 1867 and the western provinces were added soon after, this opportunity to extend the work of the Survey became a reality. By this time, however, Sir William was approaching seventy years of age, and he reluctantly appreciated the fact that the added responsibilities of exploring this new vast territory required the energy of a younger man. Accordingly, in 1869, he tendered his resignation, which was accepted, and A. R. Selwyn became his successor. For the remainder of his life Logan continued, however, his interest in geology, carrying on investigations in that area of many problems, the Eastern Townships. Part of his time was spent in England and he took occasion to visit his old friend Murray in Newfoundland. The end came in 1875 when he was visiting his sister in Wales, and he was laid to rest beside his brother Hart at Llechryd.

(To be concluded in the May issue)

LETTERS TO THE EDITOR

The Editor
Earth Science Digest.

Dear Sir:

I have subscribed to your magazine from the first issue and have many enjoyable hours reading and rereading your magazine. It is an excellent magazine and I hope that it will continue to maintain the high standards which you have set for it. . .

William L. Miller
Baltimore, Maryland

The Editor
Earth Science Digest.

Dear Sir:

I like the Earth Science Digest very much because of the very interesting articles it contains and I will always subscribe for it as long as it is published. . .

Raymond R. Hibbard
Research Associate in
Invertebrate Paleontology,
Buffalo Society of
Natural Sciences.

The Editor
Earth Science Digest.

Dear Sir:

We find your publication very enlightening. It's also very interesting for just idle reading to members of our families, who are not especially interested in becoming amateur geologists. We believe you have a fine magazine, and would like to extend our special compliments to Victor Shaw and his Lost Mine series, as well as to those who are responsible in any way for the publication of this magazine.

Robert D. Franklin
Adolph Westlind
Clatskanie, Oregon

When answering advertisements please mention *The Earth Science Digest.*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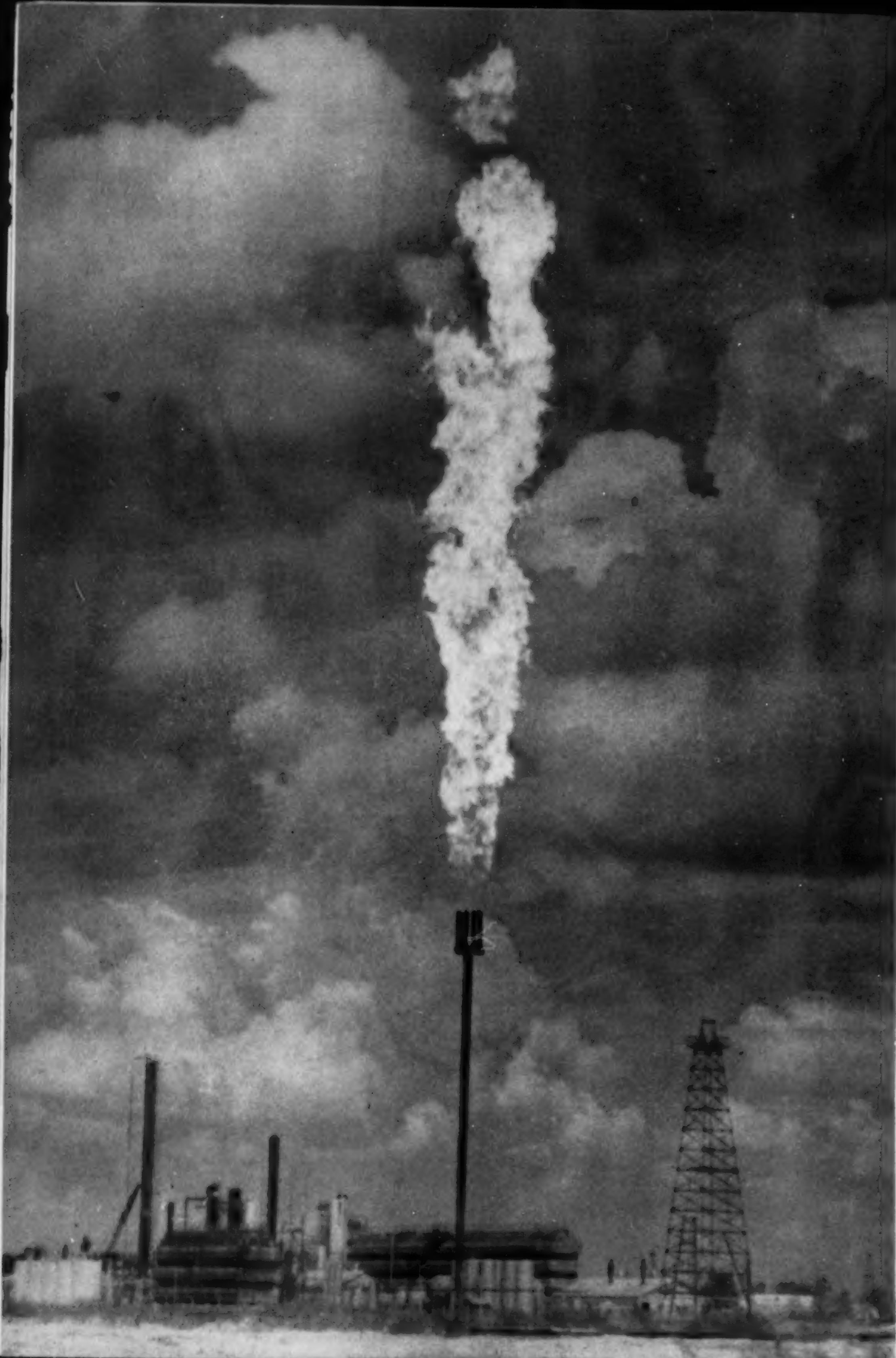


The Origin and Accumulation of Petroleum

W. D. KELLER
University of Missouri

"Breathes there a man with soul so dead,
Who never to himself hath said,"
Surely there's oil beneath my land?

With all apologies to poet Scott, we think there is "more truth than poetry" (again in the vernacular) in the last line, for who is the person who hasn't done a little wishful thinking that he had beneath his surface property a fortune in black gold that would make him independent for life. Even after a dry hole has been drilled most persons think that if it had only been bored another hundred feet deeper it would have been a gusher. What is the scientific explanation of the occurrence of this miraculous fluid which buoys optimism in the individual to the top, and for which nations today will go to war? Oil is where you find it—but earth science can save one a lot of fruitless looking.

Before plunging into the geological facts about oil and gas it may be of interest to review the factors which led up to the tremendous petroleum industry of today. We start with salt, the common table variety. Back in early colonial days, prior to 1806, the individuals sprouting our family trees liked salt on their wild turkey, green corn, and fried potatoes, even as do you and I. Salt was a scarcer commodity in those days than now, and at localities far away from the briny sea, many an animal was scared away from a salt lick or a salty spring by a lad or lassie whose chore it was to replenish the family supply of salt, and who gathered the saline seasoning where it seeped and rose from the ground. Those who made a business of supplying salt to the trade relied upon the beneficence of relied upon the beneficence of Mother Nature or else dug pits or shallow reservoir wells where saline waters (probably connate water) emerged at the surface. This story of salt will still lead us to oil, although it may be as devious as drilling a 10,000 foot well.

In 1806, two brothers, David and Joseph Ruffner, commenced a revolutionary operation by **drilling,** (something which had not been done before) by means of a steel-bitted drill, through surface soil and into hard **solid rock,** at the Great Buffalo Lick in West Virginia, a well for the purpose of increasing production of salt water (and consequently salt) at that salt lick. They were successful in their first attempt at drilling and in producing salt water, but not all future drilling by them or by competitors was so successful.

In many of the later wells drilled, their production of **salt water** was **contaminated,** even to ruination, by the accompaniment of flowing **petroleum!** How times do change, for within considerably less than 100 years the "weed became the crop", the contaminant became the objective.

Natural Gas

Natural gas was also hit by wells drilled for salt. A quotation from an article by Mr. Paul H. Price (reference at the end of this arti-

A gas flare where the residue of natural gas is being burned after the gasoline has been "stripped" out of it. Usually this gas being burned is "sour"; that is, it contains sulfur. Part of the gasoline plant and producing wells under derricks are shown in the photo.—Hobbs, New Mexico.

cle) includes a human interest story on the difficulties of a Captain James Wilson who drilled a well in 1815 within the present limits of Charleston, West Virginia.

"The Captain had not gotten as good salt water as he expected; but instead of being discouraged, he declared in language emphatic, that he would have better brine or bore the well into Hell. Shortly after this the auger struck a cavity which gave vent to an immense flow of gas and salt water. The gas caught fire from a grate near at hand, and blazed up with great force and brilliancy, much to the consternation of the well-borers and others. Captain Wilson thought it would be reckless tempting of providence to go any deeper, and ordered the boring stopped."

During these times, natural gas was usually allowed to blow to the air but occasionally was utilized to furnish light and heat. In one occurrence the rising "gas lifted salt water, 1,000 feet from the bottom of the well, forced it a mile or more through pipes, to a salt furnace, raised it into a reservoir, boiled it in the furnace, and lighted the premises at night." Other occurrences became "burning springs".

Another quotation about the well described above illustrates the general lack of knowledge in 1843 about natural gas. The well roared so loudly after drilling that it could be heard under favorable conditions for several miles.

"While this well was blowing, it was the custom of the stage drivers, as they passed down by it, to stop and let their passengers take a look at the novel and wonderful display. On one occasion, a professor from Harvard College was one of the stage passengers, and, being a man of investigating and experimenting turn of mind, he went as near the well as he could get for the gas and spray of the falling water, and lighted a match to see if the gas would burn. Instantly the whole atmosphere was ablaze, the Professor's hair and eyebrows singed, and his clothes afire. The well-frame and engine-house also took fire, and were much damaged. The professor, who had jumped into the river to save himself from the fire, crawled out, and back to the stage as best he could, and went on to Charleston, where he took to bed, and sent for a doctor to dress his burns.

"Colonel Dickinson, one of the owners of the well, hearing of the burning of his engine-house and well-frame, sent for his man of affairs, Colonel Woodyard, and ordered him to follow the unknown stage passenger to town, get a warrant, have him arrested and punished for wilfully and wantonly burning his property,—"unless you find that the fellow is a natural damned fool, and didn't know any better." Arriving at Charleston, Woodyard went to the room of the burnt Professor at the hotel, finding him in bed, his face and hands blistered, and in a sorry plight generally. He proceeded to state in very plain terms the object of his visit, at which the Professor seemed greatly worried and alarmed, not knowing the extent of this additional impending trouble, which his folly had brought upon him. Before he had expressed himself in words, however, Woodyard proceeded to deliver, verbatim, and with great emphasis, the codicil to Dickinson's instructions. The Professor, notwithstanding his physical pain and mental alarm, seemed to take in the ludicrousness of the whole case, and with an effort to smile through his blisters, replied that it seemed a pretty hard alternative, but under the circumstances, he felt it his duty to confess under the last clause, and escape. "Well," said Woodyard, "if this is your decision, my duty is ended, and I bid you good morning."

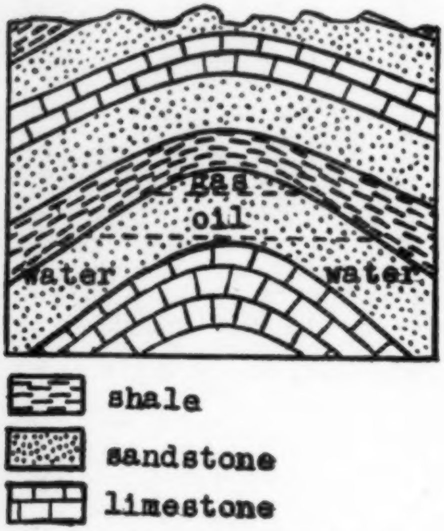
Petroleum As Medicine, Kerosene, Gasoline

The petroleum which was an incidental by-product of salt water wells in the early 19th century was sold, without being refined, as a liniment, and also as a general panacea for most ills by those less scrupulous, also occasionally as a lubricant and fuel, but more commonly as a substitute for whale oil in lamps. With the increase of man's desire for the bright lights came the refining of petroleum to produce kerosene, long a mainstay as the most widely used illuminating fluid.

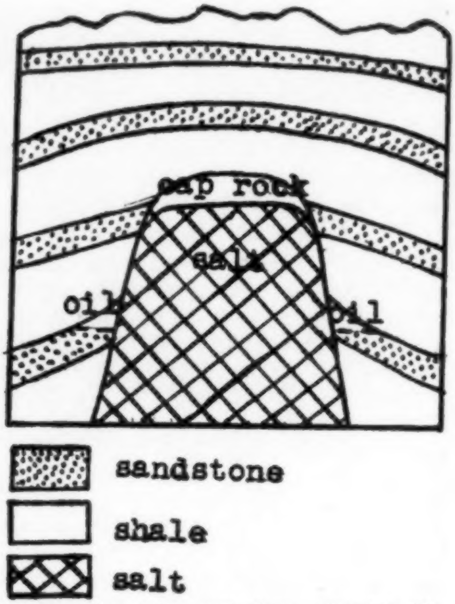
But a serious problem arose in the refining process of kerosene. Abundant gasoline, for which there was little use, came off the refiner's stills ahead of the kerosene. If it were run into the streams it became a fire and explosion hazard, and also killed the fish—that must not be done! Consequently, as much of it was run into the kerosene as the traffic would stand. To protect the innocent consumer from being furnished over-active, explosive kerosene it was necessary that kerosene inspectors be authorized whose duty it was to pass only good kerosene which was relatively free from gasoline. We suppose the idea of inspection was to keep the octane sufficiently low in the kerosene. A change came with the growth of the automobile industry and then the difficulty was to keep the kerosene out of the gasoline, and the salt water out of the **oil wells.**

The Geology of Petroleum

Petroleum (rock oil: **petra** rock, **oleum** oil) is recovered from favorable geological structures such as anticlines, faults, salt domes, and reservoir (stratigraphic) traps in which the oil is "pooled". It is a long trail back to the source of the oil from the casing head so we will start directly at the beginning. Petroleum contains certain chemical compounds which the chemist finds in derivatives of living organisms and it is therefore concluded that most of the petroleum finds its primitive origin in some living matter, either plant or animal. Some oils are presumed to be mainly plant derived, others from animals, but unquestioned tests for differentiating them have not been discovered. Most petroleum probably came from small, even microscopic-sized organisms which lived and thrived in great abundance in geologically ancient oceans. The oceans today are the homes of countless tiny floating and drifting plants and animals which would aggregate into almost unbelieveable tons and cubic miles if they could be assembled and measured. Such organic material settled or was carried down by clays to the ocean floor in astounding quantities in the geological past. Much of it underwent chemical changes which released black carbon particles which colored shales and other sedimentary rocks black and gray, but in other occurrences the chemical change was to petroleum. Chemists today have synthesized in their laboratories petroliferous fractions from organic matter. In the wide laboratory and chemical factory of Mother Nature, millions of years were available for the synthesis, and abundant clay catalysts, radioactive minerals, high pressures, adequate fluids, bacteria, and variable rock temperatures contributed their parts in the process which made the oil which is



Cross-section of a petroleum-bearing anticline.



Cross-section of a salt dome, showing the occurrence of oil in the flanking sandstone.

so eagerly sought today. There is little doubt that the same process is going on today but the short span of time we have had for confirming the idea has been inadequate to round out the story completely.

Suffice it to say that the petroliferous products were generated in the sedimentary rocks, usually clayey, which were saturated with water entrapped in them during their deposition and consolidation. Usually in nature a porous sandstone or limestone, or rarely a fractured igneous rock, was near enough that the oil migrated from the clayey source-rock to the reservoir-rock of larger pores, aided in movement by rock pressure, water drive, and capillary action between the different rock materials. Ideally, the oil moved to a porous and permeable "sand" formation which also was sealed, capped, or covered by an **impermeable** formation that held down the valuable oil. But the development of the richest type of pool has still not been arrived at. A favorable structure for the **concentration** and accumulation of the oil which was distributed widely through the "sand" is necessary to provide a pool which will feed long-lived gushers.

The classic type of structure for which oil geologists have searched for years is a dome, an anticlinal structure in all cross-sections cut through it. Here the gas concentrates at the top, next is oil, and finally water stands below, in the order of their increasing densities. Gas is dissolved in both oil and water, and indeed, all three are present and mixed in each zone. When a well is drilled into the oil saturated zone the pressure of the gas above, and the water below, may drive the oil out with sufficient force to gush above the surface of the ground. If the gas is not bled directly out of the reservoir but allowed to drive out oil, which is also made lighter by the dissolved

An anticline which is producing oil. The derricks are in the center of the structure, half of which is shown. Note the sedimentary beds which are dipping away on all sides from the center. Lander oil field near Lander, Wyoming.

gas, increased recovery of oil is possible. Sound production practice attempts to recover a maximum of the oily treasure but this can be achieved only by the co-operation of all parties drilling and producing from the structure or pool. Wells which are drilled near the outer edge of the oil zone are reached first by water encroaching up the dipping reservoir rock and are abandoned after they "make too much water". Eventually, all wells on a structure cease to flow and are pumped, later they deliver water, and finally the pool is abandoned.

Despite the popularity of anticlinal structure not all oil production comes from it. Beds of rock which were bent up along faults, around the edge of salt domes, or at unconformities have furnished their full share of oil and gas. Old buried sand-bars of rivers, sand beaches and bars from along lake or ocean shores, and isolated portions of relatively higher porosity in the various rocks have been important producers of oil.

The essentials for the origin and accumulation of petroleum are a source environment or rock, a reservoir rock, a confining cap rock, and a favorable structural condition in which collection or accumulation can occur. With these essentials met, the geologist goes out in search for the pool.

Prospecting for Oil and Gas

Perhaps the geologist first looks for an anticline or dome by observing the surface rock outcrops. For several decades this technic was the one principally (almost solely) used. Faults, as well as folds, shown by surface geology might lead the prospector to an oil pool. But after all of the potentially productive surface geology has been mapped the area must be "x-rayed" deeper to find what the rocks do beneath the visible surface. Structures hidden and buried beneath featureless surface rocks, or beneath even misleading formations which are separated by an unconformity from the structures, are "looked for" by intensive geological studies and interpretations, or by geophysical exploration.

Amazing discoveries have been made by both methods but the latter is more easily outlined in a brief review as this article is. One geophysical technic is the search for a geological deviation (structure) of the rocks by the very delicate measurement of the pull of gravity in an area which is underlain by a non-uniform distribution of rocks. If a heavy (denser, higher specific gravity) bed or plug of rocks rises toward the surface (but may not be visible) it will exert a stronger pull of gravity on a gravity meter above it than will the surrounding rocks. Hence the geophysicist or geologist measures above it during a survey an anomalous value for the gravity, and from such determinations interprets the occurrence of a geological condition beneath which may produce oil.

Another technic utilizes the anomalous magnetic forces present over some areas as against others to interpret the structure. During World War II an **air-borne** magnetometer was constructed which measured and recorded variations in the earth's magnetic pull when the instrument was flown at a high speed over the area to be explored. Incidentally, this apparatus also detected hidden and submerged enemy submarines.

A technic which has pointed to many barrels of oil is seismic, or artificial earthquake prospecting. A group of delicate seismographs which measure weak earth tremors are distributed around a "shot point" where a light charge of explosive buried a few feet beneath the surface is set off. Vibration waves from the explosion travel downward to the various beds of rock and are reflected from them like light from mirrors of varying efficiency to the seismographs. By determining the position of the "reflecting" beds of rock from the seismograph data the underlying geologic, and possibly oil producing, structure is interpreted. A variation of this method is to measure the refracted instead of the reflected wave.

Other geophysical technics utilize electrical currents or measures of radioactivity (atomic breakdown). The analogy to x-raying the earth is good, but it should be noted, however, that none of these technics registers **petroleum** or **natural gas themselves;** they help only to find geological structures.

After all of these years of prospecting the field is still wide open for the present day earth scientist or hobbyist to find oil beneath his own land by a method that locates the oil itself! Power and luck to you!

Reference, "The evolution of geologic thought in prospecting for oil and natural gas", by Paul H. Price, *Bulletin of the American Association of Petroleum Geologists*, April, 1947.

CORRECTION

"The Art of Diamond Cutting", by George R. Kaplan, which was published in the January *Earth Science Digest*, originally appeared in the July 1947 issue of *The Lapidary Journal.*

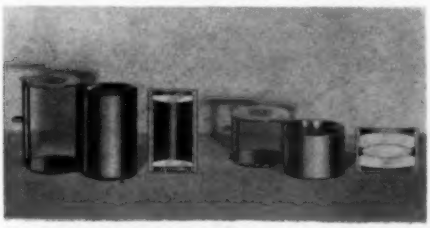
GEOLOGY AND THE MICROSCOPE

(Second of a Series)

Apparatus and Collections

JEROME M. EISENBERG

The microscope plays an important part in determinative mineralogy and geology, and should supplement ordinary chemical analysis and physical identification. An accurate qualitative determination of the chemical composition of a mineral can be obtained by means of spot and slide tests. Among the physical properties readily observable are color, streak, cleavage, fracture, inclusions, zonal growths, transparency, luster, refractive index, and crystal faces and interfacial angles. The typical chemical and physical properties of minerals and rocks will be discussed in future articles. These microscopical observations are especially useful in the identification of tiny grains and crystals.



Hand magnifiers. Doublet and Triplet, showing sectional views of each.
—Courtesy of American Optical Co.

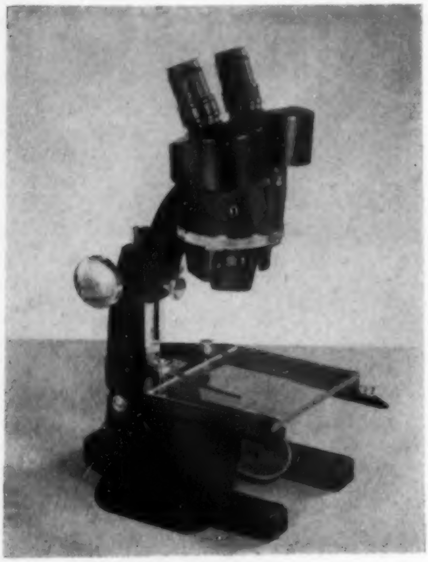
A limited amount of apparatus is needed for the majority of tests. All the above mentioned physical properties may be observed with an ordinary hand magnifier or elementary microscope. Most of the work is done with low magnifications, usually between 10 and 75 times, rarely exceeding 150. Table magnifiers and even hand magnifiers such as those illustrated above can be substituted for the microscope for these observations, and

The Polarizing Microscope.
—Courtesy of American Optical Co.

for chemical spot and slide tests.

The polarizing microscope is essential for any advanced work and for highly accurate determinations. With polarized light, one can determine whether a mineral is isotropic or anisotropic; measure extinction angles and dispersion; observe pleochroism and interference colors; etc. Until recently, due to the high cost of such a microscope, relatively few amateurs were able to afford this study; however one may now obtain polarizing microscopes, designed especially for the amateur, for as little as $30.

The stereoscopic microscope, affording a three-dimensional view, is widely used in the fields of geology, and is excellent as a



The Stereoscopic Microscope.
—Courtesy of American Optical Co.

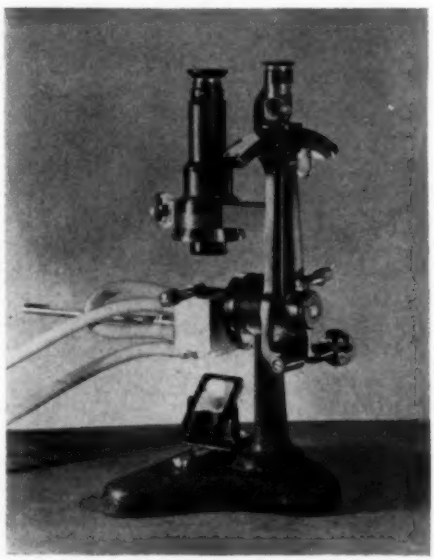
means of studying microscopic crystals and other specimens.

Practically all of the known mineral species have definite indices of refraction; that is, a ray of light entering the mineral, a denser medium than the air, is bent, or refracted, each specie having its own individual refractive values. Rarely do two minerals have the same refractive indices. By placing the unknown mineral in liquids of known indices, its refractive index is readily determined. These immersion media can be purchased in series or individually in applicator vials. For highly accurate work, the refractometer is used. By the use of tables, the refractive index may be obtained directly from the reading on the instrument. It is limited to professional use because of its expense.

The microscope lamp is either fitted under the substage of the microscope or placed in front of the mirror or the stage. A good lamp may be obtained for as little as $3.00.

Other apparatus necessary for microscopic study are microscope slides, cover glasses, lens paper, forceps, a "camel's hair" brush, and Canada balsam, which is used for mounting the specimens. A stage or ocular micrometer is helpful in measuring the size of the individual grains or crystals.

The identification of specimens is not the only use to which the collector and amateur geologist puts the microscope. Many fascinating collections intended solely for observation under the microscope or hand lens have been formed. A large number of mineral collectors have extensive collections of **micro-mounts,** specimens which may be appreciated only by microscopical means, mainly crystals. Thin sections of rocks, microfossils such as foraminifera, radiolaria, pollen grains, and spores, mineral inclusions and cavities, and sands are only a few examples. The writer has a collection of micro-mounts of isometric crystals, both single and in groups, and a



The Spencer Abbe Refractometer.
—Courtesy of American Optical Co.

series of cross-sections of **varved clay,** clay composed of layers of different thickness and composition, illustrating its annual deposition. The light-colored layers of clay were deposited during the summer, and the dark-colored layers, richer in organic material, were deposited during the winter. By counting these thin layers, it is possible to tell the age of the deposit. The enterprising collector can start many other types of collections illustrating the fascinating processes of nature.

THE COLLECTOR

This section of the Earth Science Digest is devoted to the collector of minerals, fossils, and rocks. Notes on collecting, collections, localities, etc., will be welcomed. Please address all correspondence to The Collector, c/o The Earth Science Digest, Revere, Mass.

A FOSSIL FIND IN ITALY

ANTHONY THURSTON

In April of 1945, the 34th Division, of which I was a member, returned from the mountain war of the Appenines and rested about 15 miles north of the city of Florence. We pitched our tents in a valley which had interested me several months before, when we were dodging some very accurate shots from a German "88". At that time, of course, I could not satisfy my geological curiosity, but when our rest period started, I began a series of walks in various directions. It was apparent from a nearby hillside that at one time a lake had occupied the valley. A small stream emerged from a narrow, rocky gorge in the mountains, leveled off, meandered sluggishly to another range, then quickened its pace again and plunged into a narrow exit. Terraces were faintly visible in many places but to the west a prominent shelf of sediment stood some fifty feet above the main valley floor. It was this bench which caught my eye, for I could see a large pile of black talus and a mine entrance.

At the first opportunity, I made a trip to this region and found the talus to be lignite coal. I collected several pieces which, although rather friable, showed clearly the growth rings of a tree. The mine entrance itself was blocked a few feet inside, but recent attempts had been made to sink a vertical shaft nearby. This was full of water, but the pile of clay and organic material beside it proved interesting, for I found several delicate cones which, although clearly visible, crumbled at the first touch.

Having found nothing worth collecting at the mine, I set out to investigate the brush-covered slopes of the terrace. Several erosion gullies had been formed, and it was in one of these that I found lignite in place. Several firm sections of fossil wood with the texture of the bark clearly visible were sticking out of the clay. I collected several pieces from six to twelve inches long, then continued up through the wash. Then, I saw the end of a bone, just below a thin layer of coal. I had visioned finding leaves, cones, or perhaps fresh water mollusks, but never a bone.

Bison bone from the Pleistocene lignite beds about 15 miles north of Florence, Italy.
—Photo by Anthony Thurston.

I worked rapidly, trying to exercise care, but had the fossil bone been fragile it would surely have been ruined. My luck held out, however, and soon the bone came free — intact. I hardly took time to examine my find, but searched far additional pieces, which were just not to be found. I dug about the original site for several feet, but even this drew a complete blank.

When I returned to my tent, I washed the bone and packed it up with several pieces of the wood for shipment home to the U. S. A.

Later examination added a little more information. The formation proved to be Pleistocene, according to a geological map of the region. The bone is about 10 inches long and about 1½ inches wide, rather heavy, dark brown and solid, with the finest details clearly visible. It has finally been identified as that of a bison.

PIEDMONTITE FROM MISSOURI

Piedmontite, the deep red mineral closely related to epidote, can be collected in abundance, but in small aggregates, from the rhyolite exposed in quarries near Annapolis, Missouri. Annapolis is on a hard surfaced road, Missouri State Highway No. 49, about 100 miles south of St. Louis.

The quarries were opened near the top of a rhyolite porphyry knob almost due south of the town, across the headwaters of the St. Francis River. An old quarry road, now impassable, leads up to the abandoned paving block quarries.

The piedmontite occurs in small needles which radiate in incomplete circles and in tufts and nests which occupy cavities and open joint surfaces in the rhyolite. Associated minerals are notably scanty.

Epidotization, producing the common green epidote in the porphyry, is very common throughout the igneous southeastern Missouri area. Small bodies of manganese ore have been found cutting the porphyry a number of miles north of Annapolis. At the Annapolis locality, manganese-bearing solutions apparently permeated the rock at a period which favored epidotization, and piedmontite, identical with epidote in chemical composition except for the substitution of manganese for iron, resulted.

Collectors have not been restricted from taking specimens from this occurrence.

—Prof. W. D. Keller,
University of Missouri

RECOMMENDED READING

The Earth Science Digest has selected the following articles from current periodicals as recommended reading.

PHYSICAL GEOLOGY

"The Rift Valleys of Africa". G. F. S. Hills. *American Journal of Science,* Vol. 246, No. 3 (March 1948), 171-181.

HISTORICAL GEOLOGY

"Correlation of the Mississippian Formations of North America". Mississippian Subcommittee, J. Marvin Weller, Chairman. *Bulletin of the Geological Society of America,* Vol. 59, No. 2 (February 1948), 91-196.

"Long Distance Correlation of Boulder Clays". D. F. W. Baden-Powell. *Nature,* Vol. 161, No. 4086 (February 21, 1948), 287-288.

PETROLEUM GEOLOGY

"Discovery of an Oil Field". Paul D. Foote. *Proceedings of the American Philosophical Society,* Vol. 92, No. 1 (March 8, 1948), 15-25.

"In Search of Arabia's Past". Peter Bruce Cornwall. *The National Geographic Monthly,* Vol. 93, No. 4 (April 1948), 493-522. (Sand dunes are also discussed.)

ECONOMIC GEOLOGY

"Georgia Gold Area Reactivated". John E. Kelly. *Mining World,* Vol. 10, No. 2 (February 1948), 20-22.

PETROLOGY

"A Preface to the Classification of Sedimentary Rocks". F. J. Pettijohn. *The Journal of Geology,* Vol. 56, No. 2 (March 1948), 112-117.

"A Classification of Sedimentary Rocks". Robert R. Shrock. *The Journal of Geology,* Vol. 56, No. 2 (March 1948), 118-129.

"The Megascopic Study and Field Classification of Sedimentary Rocks". *The Journal of Geology,* Vol. 56, No. 2 (March 1948), 130-165.

METEORITES

"American Meteorite Museum". H. H. Nininger. *Sky and Telescope,* Vol. 7, No. 6 (April 1948), 151-152.

Headquarters. The entire convention facilities of the Shirley-Savoy Hotel, over 14,000 square feet of exhibit and meeting space. The Lincoln Room, with stage, balcony, and lounge, is the Main Exhibit Hall. The Centennial Room, completely air conditioned, is the Fluorescence Room. The Colorado Room, acoustically treated, is the Lapidary Room.

Program. Each of the 5 Divisions of the Federation will have an educational program of demonstrations, symposia, films, and talks by speakers of national reputation. Divisions are Geology, Mineralogy, Paleontology, Gems and Lapidary, Dealers and Publications. The editors of every popular magazine in these fields will be present.

Exhibits. The leading dealers in minerals and earth science materials are reserving tables to show the latest in specimens and equipment. (Apply to M. F. Wasson, 637 U. S. National Bank Bldg., Denver 2) Club displays are open to earth science societies and their members on a noncommercial basis. Tables and standardized enclosed lighted glass cases are available to show your personal collection. (Apply to Ress Philips, 1001 Pearl, Denver 3) Space in the Fluorescence and Lapidary Rooms are also open to both dealers and noncommercial exhibitors.

Housing. Hotel, motor court, and trailer park accommodations **guaranteed** through the Housing Committee. Packages of forms are being sent to all organizations. (Write to Mrs. James B. Greenfield, Housing Chairman, 519—17th Street, Denver 2).

Banquet. Outdoor barbecue and Western entertainment, Red Rocks Park, June 15. Main banquet, Empire Room, June 16. Special luncheon for Northwest Federation, June 14; California Federation, June 15; Midwest Federation, June 16

Special Events. Practical demonstrations of **gem cutting** and jewelry making by lapidary schools. Many valuable **prizes** donated by dealers without solicitation, will be awarded free at drawings. An **auction** will be held on closing day. A **special train** will leave Chicago on the Rock Island June 12. A number of groups, including the Geological Society of Minnesota are coming in organized **caravans.** A national **dealers association** will be formed at the convention.

Field Trips. Four elaborately scheduled field trips will leave Denver in different directions on June 17, terminating beyond the borders of Colorado. Combine intensive collecting in major localities under expert guidance with scenic and recreational opportunities.

Complete Registration Fee, 25 cents

For further information, write:

RICHARD M. PEARL, Convention Chairman,

Colorado College, Colorado Springs, Colo.

WITH THE CLUBS

MONTEREY BAY MINERAL SOCIETY

The First Annual Mineral and Gem Show of the Monterey Bay Mineral Society was held February 28-29, 1948, in the Y.M.C.A. Building at Salinas, California.

The Society was organized two years ago as a Y.M.C.A. sponsored society with charter members from Monterey, San Benito, and Santa Cruz Counties, California. It now has a regular meeting attendance of from 75 to 100 persons. The Society also sponsors nine Junior Clubs of "Pebble Pups" with approximately 550 members. Meetings are held the Second Monday of each month at 7:30 p. m. at the Salinas Y.M.C.A. New members may join at any time and visitors are always welcome.

JUNIOR MINERAL EXCHANGE

The first national meeting of the Junior Mineral Exchange will be held at the American Federation of Mineralogical Societies Convention in Denver, Colorado, on June 14, 1948. The place: the Blue Spruce Room. The time: 1:00 P. M. Non-members are invited to attend. Although the regular membership is open to collectors 13 to 17 years of age, there is a Senior Membership for older collectors.

Members wishing to take part in the exhibit sponsored by the club should send a list with the description of their choicest specimens to the editor of the club Bulletin by May 15 so that a representative exhibit may be formed. Tyke Meissner, 1080 So. Gilpin, Denver 9, Colorado, will be in charge of the meeting and exhibit.

The Junior Mineral Exchange is a national organization with nearly 100 members representing 28 States.

GEORGIA MINERAL SOCIETY

The first meeting of the Gemological Section was held on Monday, February 23, 1948, and got off to a fine start under the able leadership of Mr. E. E. Joachim, Chairman. Several outstanding collections of cut and polished gems were on exhibit and more than four hundred gems were shown, including some rare and valuable pieces.

A field trip to the famous collecting area of Troupe County (near LaGrange, Georgia) was held on Saturday, February 28, 1948. The trip was led by Dr. A. S. Furcron, President of the Society, and Mr. Sam Caudle of LaGrange, Georgia. Mr. Caudle was a most gracious host, and neglected his business to conduct the party over the county to the best areas for collecting. Among the minerals collected were rose quartz, beryl, chromite, garnierite, and tourmaline. Sixteen members were present, the inclement weather of the day before and the threatening weather at leaving time being responsible for the small attendance.

On Monday evening, March 1, 1948, the Society met in the Civil Engineering Building of the Georgia School of Technology. Dr. Horace G. Richards, Associate Curator of Geology and Paleontology of the Academy of Natural Sciences of Philadelphia, spoke on "The Colorado Delta", illustrating his talk with Kodachrome slides. Dr. Richards outlined the history of the Colorado River from 1907 to the present time with emphasis on the international complications arising from the diversion of the waters from their natural course without regard to the geology of the area. Four new members were welcomed into the Society.

ALBUQUERQUE GEM AND MINERAL CLUB

At the February meeting of tthe Albuquerque Gem and Mineral Club, Mr. William Parker gave a talk on his first visit to the Bingham Mine District of Utah in 1889. The Club had an annual display at the State Fair in conjunction with the New Mexico Bureau of Mines and Mineral Resources.

DONA ANA COUNTY ROCKHOUND CLUB

This is now the official name of the recently organized mineral club in New Mexico. The name was adopted at the second regular meeting of the club, which was held on Friday, February 13, 1948. Edwin Archer spoke on "The Hardness of Minerals", and Ruth A. Perkins gave a talk on "Gems." Committees were appointed for the arrangement and management of field trips.

THE DIRECTORY

ARIZONA

L. E. BAGG. Arizona mineral specimens. Box 782, Peoria.

CALIFORNIA

HEALD-ROBINSON. Geologic and scenic color slides. 2202 N. Santa Anita Avenue, Altadena.

MRS. E. CAILLAND. Gem cutting material. Mineral specimens. 3642 Gerdenia Avenue, Long Beach.

THE SILVER MINE. Lapidary equipment and supplies. Books. Mineralights. 908 N. Ave 54, Los Angeles.

BURMINCO. Mineral specimens. Gem materials. Fluorescents. 128 South Encinitas, Monrovia.

POLY PRODUCTS. Poly grinders. Rockhound Saw Arbors. 406 S. Chester Ct. 1C, Pasadena.

S-T GEM AND MINERAL SHOP. Lapidary equipment and supplies. Cutting material. 6924 Foothill Blvd., Tujunga.

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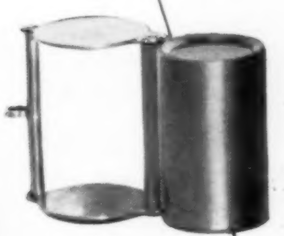

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